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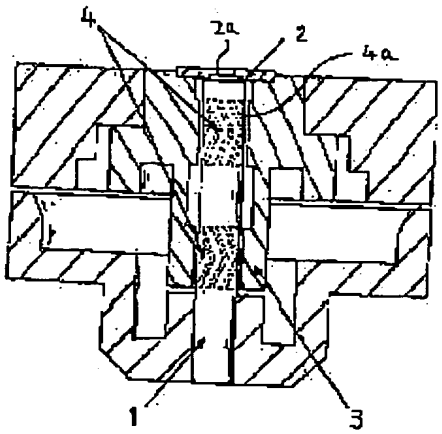
## (54) DYNAMIC PRESSURE BEARING




(57)Abstract:

PROBLEM TO BE SOLVED: To provide a dynamic pressure bearing which does not cause any convenience caused by a difference in thermal expansion even though the temperature varies.

SOLUTION: A dynamic pressure bearing 2 made of ceramic having a Young' s modulus not less than 200 GPa, a thermal expansion coefficient of 9.0 to 11.0 ×10-6/deg.C (40 to 400 deg.C), and a difference in Vickers hardness between the ceramic and a slidable mated member, which is at most 7 GPa, is formed in its slide surface with a dynamic pressure inducing groove 2a. Zirconia ceramic

having a bending hardness not less than 700 GPa, a mean particle diameter at most 4 $\mu$m, and a relative density not less than 98% with respect to the theoretical density thereof is preferably used as the above-mentioned ceramic. Further, the surface roughness (Rmax) of the bottom surface of the dynamic pressure inducting groove 2a is at most 1.5 $\mu$m.

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CLAIMS

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[Claim(s)]

[Claim 1] The hydrodynamic bearing to which Young's modulus is characterized by having consisted of ceramics with which 200 or more GPas and the coefficient of thermal expansion in 40-400 degrees C have the difference of Vickers hardness with 9.0 - 11.0x10-6/degree C and sliding partner material in the range of 7 or less GPas, and equipping a sliding surface with a dynamic pressure generating slot.

[Claim 2] The hydrodynamic bearing according to claim 1 characterized by relative density [ as opposed to 700 or more MPas of flexural strength, 4 micrometers or less of diameters of average crystal grain, and theoretical density in the above-mentioned ceramics ] consisting of 98% or more of zirconia ceramics.

[Claim 3] The hydrodynamic bearing according to claim 1 characterized by the surface roughness (Rmax) of the base of the above-mentioned dynamic pressure generating slot being 1.5 micrometers or less.

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DETAILED DESCRIPTION

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[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the hydrodynamic bearing used for the bearing of the shaft in the polygon mirror of a laser beam printer, a floppy disk drive (FDD), a hard disk drive (HDD), VTR, CD-ROM, etc.

[0002]

[Description of the Prior Art] Conventionally, although the bearing of a shaft had taken the structure which accumulated the ball bearing and the oil impregnation bearing, various troubles have generated it with thin-shape-izing of a product, and high-performance-izing. For example, when achieving thin shape-ization of spindle motors, such as FDD equipment, it is necessary to shorten a bearing but, and an axial deflection becomes large as it shortens. Thereby, the eccentricity of media became large and the trouble that the dependability of data R/W fell remarkably occurred.

[0003] As a solution means of such a trouble, the hydrodynamic bearing in which dynamic pressure generating slots, such as a spiral slot, were formed was developed. According to the pumping operation which a spiral slot gives to a lubrication fluid, this acquires lifting of the oil pressure accompanying the revolution of a spindle motor, surfaces a shaft, forms liquid film, and rotates by no contacting. Furthermore, the eccentricity of a shaft can also be remarkably stopped by giving the centering effectiveness by oil pressure.

[0004] As a configuration of a hydrodynamic bearing, a dynamic pressure generating slot is formed in the periphery of a shaft, or either of the sleeve inner surfaces, and it consists of radial bearing with the rigidity of a radial direction, and thrust bearing which forms a spiral-like dynamic pressure generating slot in the end face of a shaft, or the front face of thrust bearing, and has the rigidity of the thrust direction

according to a pumping operation of lubrication fluids, such as oil and a gas.
[0005] Here, an important element is the hydrodynamic bearing of the thrust direction. That is, since the radial direction in a vertical mold motor has the almost equal outer diameter and sleeve bore of a shaft, it is sufficient for a blemish just with contact, and it does not have most things which a sliding surface exfoliates.
[0006] On the other hand, the bearing of the thrust direction will require all thrust force, such as a self-weight of the revolution section, and a suction force of a stator, for the sliding surface of a shaft and thrust bearing, and in order that a mutual sliding surface may carry out a contact revolution at the time of a start stop and a low-speed revolution, it has important effect to endurance. Moreover, each the shaft and bearing which constitute this hydrodynamic bearing were using quenching material, such as stainless steel, conventionally.
[0007] However, when it consists of metal comrades, wear arises by contact of a metal comrade, and the generated wear powder enters the clearance between bearing, and there are problems, such as producing galling printing. That is, in the long-term activity, it had the problem in respect of dependability by the behavior of the complicated contact problem at the time of starting by the slot which carried out the sharp cross-section configuration (cut with a slot edge), and lubricant etc.
[0008] Then, as shown in JP,63-163016,A etc., forming this hydrodynamic bearing with the ceramics is proposed. This formed with the ceramics either the shaft which constitutes a hydrodynamic bearing, or bearing, formed the dynamic pressure generating slot in the front face by the shot-blasting method etc., and formed another side by metal material.
[0009]
[Problem(s) to be Solved by the Invention] However, when either a shaft or bearing was formed with the ceramics as mentioned above and another side was formed with a metal, the inconvenience by the difference of both property had arisen. For example, since coefficients of thermal expansion differed, the magnitude of the clearance between both changed and the ceramics and metal material had inconvenience, such as producing trouble in a revolution of a motor, when the temperature of the interior, such as a motor using a hydrodynamic bearing, went up to 100 degrees C.
[0010] Moreover, since the degree of hardness of ceramics was very high compared with metal material, when both slid at the time of a low-speed revolution etc., there was a problem of wearing a metal material side out greatly. In addition, in order to solve this problem, forming the member of both which slide with the ceramics was also considered, but when both were formed with the same construction material, there

was inconvenience of on the contrary becoming easy to wear out.
[0011] Furthermore, generally, ceramic material had the problem of being easy to damage when an impact joins bearing, when the hydrodynamic bearing using the ceramics was used for pocket devices, such as a notebook computer, since reinforcement was low compared with metal material.
[0012] Moreover, although the base of a dynamic pressure generating slot needed to be smoothed in the hydrodynamic bearing in order to be stabilized and to make liquid film hold, in the dynamic pressure generating slot formed in ceramic material by the shot-blasting method, about 1 micrometer was not able to be processed by arithmetical mean deviation of profile (Ra), and surface roughness at the bottom was not able to be processed into about 4 micrometers with the maximum height (Rmax).
[0013]
[Means for Solving the Problem] Then, the difference of Vickers hardness with Young's modulus [ of 200 or more GPas ], coefficient-of-thermal-expansion [ of 40-400 degrees C ] 9.0 - 11.0x10-6/degree C and sliding partner material consists of ceramics in the range of 7 or less GPas, and this invention is characterized by constituting a hydrodynamic bearing for a dynamic pressure generating slot in preparation for a sliding surface.
[0014] That is, if one side of a shaft and bearing is formed by the hydrodynamic bearing of the above-mentioned ceramics and another side is formed by metal material, by considering as above-mentioned [ the coefficient of thermal expansion of a hydrodynamic bearing ] within the limits, even if a temperature change arises, the inconvenience by the differential thermal expansion is cancelable [ a differential thermal expansion with metal material is made small, and ]. And by setting the difference of Vickers hardness with a sliding partner's metal material to 7 or less GPas, since the hardness difference is comparatively small, even if it slides at the time of a low-speed revolution, wear of partner material can be lessened.
[0015] Moreover, this invention is characterized by the relative density to 700 or more MPas of flexural strength, 4 micrometers or less of diameters of average crystal grain, and theoretical density using 98% or more of zirconia ceramics as the above-mentioned ceramics.
[0016] Here, the zirconia ceramics of 700 or more MPas of flexural strength were used, because it was it easier to damage by the impact from the outside that flexural strength is less than 700 MPas and stopped achieving the function as bearing or a motor. Furthermore, in addition, the above-mentioned zirconia ceramics have that desirable whose fracture toughness is 5.0 or more MParootm. This is for the problem

that are it easy to produce a chip around a dynamic pressure generating slot etc. that fracture toughness is less than 5.0 MParootm, and a motor does not stop owing to the chipped fragment, or the stable dynamic pressure effectiveness is not acquired to occur.

[0017] Moreover, the diameter of average crystal grain was made to 4 micrometers or less, and relative density was made into 98% or more for the problem that the diameter of average crystal grain cannot carry out the base of a dynamic pressure generating slot to it being larger than 4 micrometers, or relative density being less than 98% smoothly, and the stable dynamic pressure effectiveness is not acquired from the channel depth of a dynamic pressure generating slot not being processible into high degree of accuracy, but revolution deflection becomes large occurring. The diameter of average crystal grain has 3 micrometers or less and good 0.5 more micrometers or less more preferably. Moreover, 99.0% or more of relative density is desirable.

[0018] Moreover, this invention is characterized by the surface roughness (Rmax) of the base of the above-mentioned dynamic pressure generating slot being 1.5 micrometers or less.

[0019] That is, by making a base into the above smooth fields, it is stabilized, liquid film is generated and the revolution deflection of a shaft can be made small.

[0020]

[Embodiment of the Invention] Hereafter, the operation gestalt of this invention is made into an example, and the hydrodynamic bearing equipment of the spindle motor for VTR is explained.

[0021] As shown in drawing 1 , hydrodynamic bearing equipment consists of the shaft 1, the dynamic pressure thrust bearing 2, and the sleeve 3 which attached body of revolution, sets a fixed shaft as this shaft 1, and a sleeve 3 rotates it. Moreover, the slot 4 of a herringbone configuration is formed in the inner circumference of this sleeve 3, or one of the peripheries of this shaft 1, the hydrodynamic bearing of a radial direction is constituted, spiral-like slot 2a is formed in the sliding surface of the dynamic pressure thrust bearing 2, and the hydrodynamic bearing of the thrust direction is constituted.

[0022] Therefore, although it will be in a non-contact condition according to the dynamic pressure effectiveness at the time of a revolution, at the time of a start stop and a low-speed revolution, the head of a shaft 1 will slide with the dynamic pressure thrust bearing 2, and the head and the dynamic pressure thrust bearing 2 of a shaft 1 will be joined by the full load of body of revolution as a load.

[0023] And this thrust bearing 2 is formed from the ceramics which has the difference

of Vickers hardness with 200 or more GPas [ of Young's modulus ], coefficient-of-thermal-expansion 9.0 - 11.0x10-6/degree C (40-400 degrees C), and sliding partner material in the range of 7 or less GPas. Moreover, the shaft 1 is formed by metal material, such as stainless steel.

[0024] Therefore, since it is the high rigidity of 200 or more GPas of Young's modulus, slot 2a is processible into high degree of accuracy. Moreover, since a coefficient of thermal expansion is 9.0 - 11.0x10-6/degree C, a differential thermal expansion with the stainless steel (coefficient-of-thermal-expansion 10.5x10-6/degree C) which constitutes a shaft 1 is small, and can make change of a clearance small also in the time of an elevated temperature.

[0025] Furthermore, even if both slide on the ceramics which accomplishes this thrust bearing 2 at the time of a low-speed revolution by setting to 7 or less GPas the difference of Vickers hardness with the metal which accomplishes the shaft 1 which is a sliding partner, it can make small wear by the side of a shaft 1.

[0026] Especially as ceramics which accomplishes such thrust bearing 2, the zirconia ceramics of 5.0 or more MParootm of fracture toughness are [ 700 or more MPas of flexural strength ] still more desirable.

[0027] These zirconia ceramics have the coefficient of thermal expansion of 40-400 degrees C almost equivalent to 10.5x10-6/degree C and stainless steel (coefficient-of-thermal-expansion 10.5x10-6/degree C). Moreover, it is set to GPa(s), and since it is the difference of 7 or less GPas mentioned above, a difference with the stainless steel (Vickers hardness 6.4GPa) with which, as for these zirconia ceramics, Vickers hardness accomplishes a shaft 1 with 12.3GPa(s) can make small wear by the side of the 5.9 shaft 1.

[0028] Moreover, even when using the zirconia ceramics of high intensity and high toughness in this way, and a strong impact is added from the outside or equipment is dropped, a possibility that thrust bearing 2 may be damaged can be used good over a long period of time, without there being nothing and producing trouble in a revolution of a motor. In addition, since reinforcement and toughness are high in this way, the hydrodynamic bearing of this invention can be used for HDD of the notebook sized personal computer which carries out an others and desktop mold and carrying of the spindle motor of VTR, the spindle motor of FDD and LBP, etc.

[0029] Furthermore, as for the zirconia ceramics which accomplish the above-mentioned thrust bearing 2, it is desirable to have considered as 98% or more of relative density to 4 micrometers or less of diameters of average crystal grain and theoretical density, and thereby, when they process slot 2a with shot blasting etc.,

they can set surface roughness of the base to 1.5 micrometers or less with the maximum height (Rmax). Consequently, it can be stabilized and the liquid film for dynamic pressure generating can be generated. Consequently, the revolution deflection of a spindle motor can be made small.

[0030] For example, in the field of a magnetic recording medium, the number of trucks per inch has been increasing every year for the improvement in recording density. Although it is indispensable that the deflection of a spindle motor is small for that purpose, if the hydrodynamic bearing of this invention mentioned above is used, the channel depth of a dynamic pressure generating slot is processed into high degree of accuracy, the stable dynamic pressure effectiveness can be acquired from the ability of surface roughness of a groove bottom to be smoothed, the revolution deflection of a spindle motor can become small, and the recording density of a hard disk etc. can be raised.

[0031] In addition, it can also be made reverse, although the dynamic pressure thrust bearing 2 which constitutes a hydrodynamic bearing was formed by the above-mentioned zirconia ceramics and the shaft 1 was formed with the metal in the above operation gestalt. Or one side of a shaft 1 and a sleeve 3 can also be similarly formed by the above-mentioned zirconia ceramics about the bearing of a radial direction.

[0032] For example, although the clearance between both is very as small as about several micrometers and the temperature inside a motor amounts also to 100 degrees C at the time of an activity when a shaft 1 is formed by the above-mentioned zirconia ceramics and a sleeve is formed by the above-mentioned stainless steel material As mentioned above, since both coefficient of thermal expansion is equivalent, the clearance between a shaft 1 and a sleeve 3 can be used good over a long period of time, without not changing a lot but producing trouble in a revolution of a motor.

[0033] Moreover, although stainless steel was used as sliding partner material of the hydrodynamic bearing made from a zirconia in the above-mentioned example, it is the same even when other metal material, ceramics, etc. are used as partner material.

[0034] by the way, the zirconia ceramics used by this invention -- ZrO2 a principal component -- carrying out -- as a stabilizing agent -- Y2 O3, MgO, CaO and CeO2, and Dy 2O3 etc. -- more than a kind is contained and what made the crystal of ****** the subject is used. especially -- as a stabilizing agent -- Y2 O3 2-4-mol % -- what is contained, and CeO2-Dy 2O3 the sum total -- 5-8-mol % -- what is contained, and MgO -- 8-15-mol % -- what is contained is desirable.

[0035] And it can fabricate by a well-known press-forming method etc. in a

predetermined configuration using the raw material powder of the above-mentioned presentation, and the hydrodynamic bearing of this invention can be obtained by calcinating the acquired Plastic solid at 1300-1500 degrees C, and processing a dynamic pressure generating slot on the front face.

[0036] 4 micrometers or less of 3 micrometers or less of diameters of average crystal grain of a final sintered compact are preferably set to 0.5 micrometers or less still more preferably, and the relative density to theoretical density is made to become 99% or more preferably 98% or more by adjusting the particle size and the baking conditions of raw material powder at this time.

[0037] Moreover, when forming a dynamic pressure generating slot in the front face of the obtained sintered compact, the shot-blasting method is used. For example, in the case of the dynamic pressure thrust bearing 2, slot 2a of a predetermined configuration can be formed by forming masking of the configuration corresponding to spiral-like slot 2a in the front face of plate-like zirconia ceramics, and performing shot-blasting processing from on this. Moreover, at this time, when the diameter of average crystal grain of zirconia ceramics is 4 micrometers or less and relative density is 98% or more, the depth of slot 2a by shot blasting can be processed into high degree of accuracy, and surface roughness of that base can be smoothed with the maximum height (Rmax) of 1.5 micrometers or less.

[0038] Furthermore, if beveling of minute C side or the Rth page is formed in the edge section of slot 2a which carried out in this way and was formed, the chipping of the edge section can be prevented and it is more suitable.

[0039]

[Example] the example 1 of an experiment -- in order to first investigate the abrasion resistance of the metal shaft 1 which constitutes the hydrodynamic bearing of this invention, and the dynamic pressure thrust bearing 2 made from the ceramics, and sliding nature, the basic trial using the friction abrasion test of a ball-on disk mold was performed.

[0040] The sample of the zirconia ceramics in a table 1 was prepared as this invention example, and each sample of the alumina system ceramics, the silicon nitride system ceramics, and the silicon carbide system ceramics was prepared as an example of a comparison.

[0041] The ball of stainless steel (SUS304: Vickers hardness 6.4GPa) is used for partner material for each sample in the condition under dry type non-lubrication, a sliding trial is performed by 0.1kg of loads, the relative sliding rate 0.1 - 5 m/s, and the result of having measured coefficient of friction, the abrasion loss of each sample, and

the abrasion loss of partner material is shown in a table 1. In addition, the ratio at the time of setting coefficient of friction of zirconia ceramics with a rate of 0.1m [/s ], abrasion loss, and partner material abrasion loss to 1, respectively showed the result. Moreover, the difference of Vickers hardness with the stainless steel which accomplishes a ball was also searched for about each construction material.

[0042] In order that the difference of Vickers hardness might exceed 7GPa(s), No.2-4 which are an example of a comparison had the large abrasion loss of partner material (ball), so that clearly from a table 1. On the other hand, since the difference of Vickers hardness was 7 or less GPas, the abrasion loss of the partner material in a low speed was small, and coefficient of friction was also low at No.1 of this invention example. In addition, since sliding in the low-speed field in which a shaft and bearing contact is the most important at a hydrodynamic bearing although the abrasion loss of the partner material in a high-speed field was large, a shaft already surfaces according to the dynamic pressure effectiveness in a high-speed field and it will be in a non-contact condition in this invention example, it is satisfactory in any way.

[0043] The differential thermal expansion of the alumina was [ 7.1x10-6/degree C and silicon carbide / 4.0x10-6/degree C and silicon nitride ] moreover, all as large as 2.6x10-6/degree C, when the coefficient of thermal expansion of 40-400 degrees C of each construction material was compared to a stainless coefficient of thermal expansion being 10.5x10-6/degree C. On the other hand, the coefficient of thermal expansion of zirconia ceramics was almost equivalent to 10.5x10-6/degree C and stainless steel.

[0044]

[A table 1]

| | No | 材質 | 硬度差 (GPa) | | 速度 (m／s) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | 0.1 | 0.5 | 1.0 | 3.0 | 5.0 |
| 本発明 | 1 | ジルコニア | 5.9 | 摩擦係数 | 1 | 2 | 2 | 2 | 1 |
| | | | | 摩耗量 | 1 | 1 | 1 | 1 | 1 |
| | | | | 相手材摩耗量 | 1 | 1 | 1 | 68 | 56 |
| 比較例 | 2 | アルミナ | 10.3 | 摩擦係数 | 3 | 3 | 3 | 3 | 2 |
| | | | | 摩耗量 | 5 | 1 | 10 | 8 | 5 |
| | | | | 相手材摩耗量 | 23 | 94 | 19 | 44 | 68 |
| | 3 | 窒化珪素 | 7.8 | 摩擦係数 | 3 | 4 | 3 | 2 | 2 |
| | | | | 摩耗量 | 96 | 117 | 143 | 1 | 1 |
| | | | | 相手材摩耗量 | 19 | 25 | 167 | 63 | 70 |
| | 4 | 炭化珪素 | 17.1 | 摩擦係数 | 3 | 3 | 3 | 3 | 2 |
| | | | | 摩耗量 | 1 | 1 | 10 | 26 | 13 |
| | | | | 相手材摩耗量 | 5 | 2 | 7 | 31 | 25 |

[0045] The example 2 of an experiment, next the dynamic pressure thrust bearing 2 shown in drawing 1 were formed with various construction material, and the trial which measures the difference in the amount of revolution deflection of the motor by the difference in the surface roughness of the impact test for investigating the shock resistance and the groove bottom of a dynamic pressure generating slot was performed.

[0046] As this invention example, as shown in No.1-3 of a table 2, it is Y2 O3 [ three mol % ] as a stabilizing agent. What is [ diameter / of average crystal grain ] different was prepared by changing the baking condition using the contained partial stabilization zirconia ceramics. Moreover, as shown in various ingredients other than the zirconia shown in No.4-8 of a table 2, and No.9-11 as an example of a comparison, even if it was zirconia ceramics, relative density, flexural strength, and the diameter of average crystal grain prepared what has this invention out of range.

[0047] Respectively, the 3mmx4mmx50mm test piece was prepared, and flexural strength was measured by three-point bending by span 30mm. Moreover, the fracture toughness value was computed from the magnitude of the crack by the indentation method, and the diameter of average crystal grain was measured by the code method. Furthermore, theoretical density was computed from the weight ratio of each component, and relative density was computed by the ratio with the apparent specific gravity measured actually.

[0048] In addition, what is necessary is to perform the same bending test using what processed this dynamic pressure thrust bearing 2 self or this into the predetermined configuration, and just to change the acquired value into the reinforcement in a JIS test piece by well-known technique, when measuring by the dynamic pressure thrust bearing 2 which is a final product although flexural strength was measured in this example of an experiment with the test piece specified to JIS.

[0049] Next, using various ingredients, the dynamic pressure thrust bearing 2 with a diameter [ of 10mm ] and a thickness of 1mm was formed, and with a depth of 5 micrometers slot 2a was formed in the front face by the shot-blasting method. The base of this slot 2a was measured with the surface roughness plan, and it asked for the maximum height (Rmax), and the depth of two or more slot 2a with the same surface roughness plan was investigated, and that amount of variations was calculated.

[0050] Then, this dynamic pressure thrust bearing 2 was included in the equipment of drawing 1 , and the impact test of 300G was performed. Moreover, the amount of revolution deflections of the shaft 1 at the time of including each sample in a spindle motor and making it rotate by 5000rpm was measured, and the condition after 100,000

cycle ****** was further investigated for the start stop trial. These results are shown in a table 3. As for the thing of 700 or less MPas, the flexural strength of No.4-10 of the example of a comparison had generated deformation, the crack, the chip, and the crack as a result of the impact test so that clearly from tables 2 and 3. moreover, No.4- as a result of the start stop trial, the load current increased and the thing of 7 and 9 had the inconvenience of a motor stopping. Furthermore, No.11 of the example of a comparison had the surface roughness (Rmax) of a groove bottom side as large as 2 micrometers, in order that the diameter of average crystal grain might exceed 4 micrometers, and as a result, its revolution deflection of a shaft was as large as 0.15 micrometers.

[0051] To these, since No.1-3 which are this invention example were 700 or more MPas of flexural strength, and 5.0 or more MParootm of fracture toughness, after the impact test was normal. Moreover, since it was 4 micrometers or less of diameters of average crystal grain, and 98% or more of relative density, depth variation of slot 2a could be made small with 1.0 micrometers, and surface roughness (Rmax) of the base of slot 2a was able to be smoothed with 1.5 micrometers. Consequently, the amount of revolution deflections of a shaft could be made very small with less than 0.1 micrometers, and the result of a start stop trial was also normal.

[0052] especially -- No. -- especially the thing made into 99% or more of relative density and 0.5 micrometers or less of diameters of average crystal grain like 1 and 2 could make reinforcement and toughness high, and was suitable.

[0053]

[A table 2]

| | No | 材　　質 | 相対密度（%） | 曲げ強度 MPa | 破壊靭性（MPa√m） | 平均結晶粒径（μm） | 溝深さバラツキ（μm） | 溝底粗さ（μm） |
|---|---|---|---|---|---|---|---|---|
| 本発明 | 1 | ジルコニア | 99.5 | 980 | 6.7 | 0.3 | 1.0 | 1.5 |
| | 2 | ジルコニア | 99.0 | 1370 | 5.9 | 0.3 | 1.0 | 1.5 |
| | 3 | ジルコニア | 98.7 | 880 | 5.3 | 3.0 | 1.0 | 1.5 |
| 比較例 | 4 | ＳＫＨ | — | — | — | — | 1.0 | 3.0 |
| | 5 | アルミナ | — | 270 | 3.5 | 4.1 | 1.5 | 4.5 |
| | 6 | アルミナ | — | 320 | 3.7 | 3.8 | 1.5 | 4.0 |
| | 7 | ﾁﾀﾝ 酸ｶﾙｼｳﾑ | — | 320 | 2.0 | 2.5 | 1.0 | 3.5 |
| | 8 | 窒化ケイ素 | — | 590 | 5.7 | 4.1 | 1.0 | 4.0 |
| | 9 | ジルコニア | 97.2 | 500 | 4.7 | 2.0 | 1.5 | 4.0 |
| | 10 | ジルコニア | 98.4 | 560 | 5.2 | 2.5 | 1.0 | 3.0 |
| | 11 | ジルコニア | 99.2 | 730 | 6.7 | 4.2 | 1.0 | 2.0 |

[0054]

[A table 3]

| | No | 材　　質 | 衝撃試験結果 | 回転ふれ（μm） | ｽﾀｰﾄｽﾄｯﾌﾟ試験によるモーターの状態 |
|---|---|---|---|---|---|
| 本発明 | 1 | ジルコニア | 異常なし | ＜0．1 | 異常なし |
| | 2 | ジルコニア | 異常なし | ＜0．1 | 異常なし |
| | 3 | ジルコニア | 異常なし | ＜0．1 | 異常なし |
| 比較例 | 4 | ＳＫＨ | 変形 | 0．2 | 負荷電流３倍に増加 |
| | 5 | アルミナ | ｽﾗｽﾄ割れ | 0．5 | ５万ｻｲｸﾙでｽﾄｯﾌﾟ |
| | 6 | アルミナ | ｽﾗｽﾄ割れ | 0．4 | ６万ｻｲｸﾙでｽﾄｯﾌﾟ |
| | 7 | ﾁﾀﾝ 酸ｶﾙｼｳﾑ | ｽﾗｽﾄ割れ | 0．3 | ２万ｻｲｸﾙでｽﾄｯﾌﾟ |
| | 8 | 窒化ケイ素 | 溝部欠け大 | 0．4 | 異常なし |
| | 9 | ジルコニア | クラック | 0．4 | ８万ｻｲｸﾙで異常音 |
| | 10 | ジルコニア | クラック | 0．25 | 異常なし |
| | 11 | ジルコニア | 異常なし | 0．15 | 異常なし |

[0055]

[Effect of the Invention] According to this invention, thus, 200 or more GPas [ of Young's modulus ], coefficient-of-thermal-expansion 9.0 - 11.0x10-6/degree C (40-400 degrees C), The difference of Vickers hardness with sliding partner material

consists of ceramics in the range of 7 or less GPas, and a dynamic pressure generating slot by having constituted the hydrodynamic bearing in preparation for a sliding surface Even if a temperature change arises, ** which cancels the inconvenience by the differential thermal expansion is made, and moreover, even if it slides at the time of a low-speed revolution, wear of partner material can be lessened. [0056] Moreover, according to this invention, when 700 or more MPas and the diameter of average crystal grain consisted of 4 micrometers or less and zirconia ceramics of 98% or more of relative density and flexural strength constituted the hydrodynamic bearing for the dynamic pressure generating slot in preparation for a front face, shock resistance can be raised, a revolution deflection can be made small, and the hydrodynamic bearing which brings about high dependability and reinforcement can be obtained.

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[Translation done.]

* NOTICES *

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## DESCRIPTION OF DRAWINGS

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[Brief Description of the Drawings]

[Drawing 1] It is drawing of longitudinal section showing the hydrodynamic bearing equipment of this invention operation gestalt.

[Description of Notations]

1: Shaft

2: Dynamic pressure thrust bearing

3: Sleeve

4: Dynamic pressure radial bearing

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[Translation done.]

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DRAWINGS

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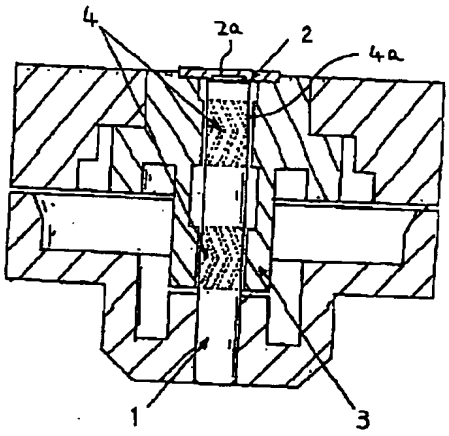
[Drawing 1]

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[Translation done.]